

A Study of the Role of the Coronal Mass Ejections in Cosmic Ray Modulation

BRIJESH KUMAR MISHRA¹, PANKAJ K. SHRIVASTAVA*
and R. K. TIWARI²

*¹Department of Physics, Govt. P. G. Science College,
Rewa - 486001 M. P., India.

²Department of Physics, Govt. New Science College,
Rewa – 486001 M. P., India.

ABSTRACT

We have analyzed the relationship between cosmic ray intensity (CRI) and occurrence of coronal mass ejections (CMEs) of interplanetary solar activity for epochs of negative ($A < 0$) mixed and positive ($A > 0$) polarities of the general magnetic field of sun during solar cycle 23. In the present analysis CMEs are used as cosmic ray modulation parameter instead of sunspot number. Our analysis reveals a positive and high correlation between R_z and CMEs. In this analysis CMEs has been used as a solar parameter for long term cosmic ray modulation. Negative and normal correlations are found between No. of occurrence of CMEs and cosmic rays for whole period.

Keywords: Cosmic rays, CME occurrence, solar cycle.

INTRODUCTION

In cosmic ray modulation, the sunspot number (R_z) has been used as a reliable solar parameter for long time. In addition to sunspot number, many other solar indices such as grouped solar flares, solar radio flux (2800MHz), area of coronal holes tilt angle of neutron current sheet, coronal index have been used to explain the characteristics of long-term cosmic ray modulation¹⁻⁴. Sabhah *et al.*⁵ (2003) found a good correlation between CHA (Coronal

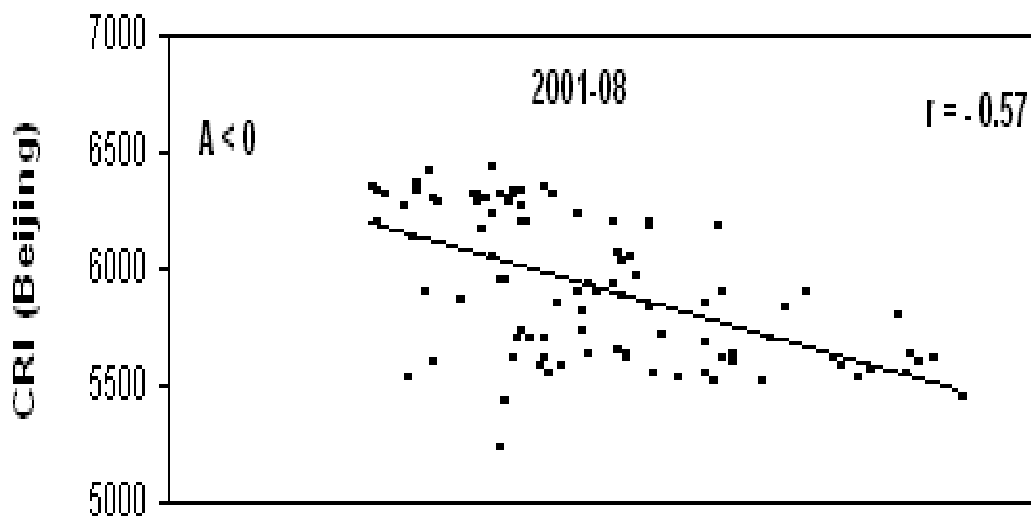
Hole Area) and CRI ($r = 0.89-0.93$) during the period of 1953 to 2001. Shrivastava *et al.*⁶ (2001) and Tiwari *et al.*⁷ (2007) have investigated coronal index (CI) as useful and appropriate solar parameter in cosmic ray modulation. After the identification of CMEs in 1974 and observations of CME data from 1996 it is now accepted its role in interplanetary disturbances and perturbation in interplanetary magnetic field. Now it is also essential to study the role of CMEs in cosmic ray modulation process on long-term as well as short-term basis. Recently,

Mishra *et al.*⁸ (2010) studied the relationship between CME rates and CRI considering the time lag analysis. They have reported high correlation during -1 day time lag. In this work, we have extended the study with a slight different approach; a correlative analysis has been performed between No. of occurrence of CMEs and cosmic rays for the periods of different epochs of solar magnetic field for the solar cycle 23.

RESULTS AND DISCUSSION

The No. of occurrence of CMEs per month has been counted from the LASCO-CME catalogue for the period of 1996-2008. The cosmic rays monthly mean values of Beijing neutron monitor station (latitude 54.34, longitude 10.12, cutoff rigidity 2.29 GV) have been used in this correlative analysis. We have correlated the CME occurrence per month against the monthly mean values of sunspot number (R_z) shown in figure 1 and CME occurrence per month

versus CRI shown in figure 2 for $A>0$ (2001-2008), $A<0$ (1996-1999) and mixed polarity (2000) epochs of solar magnetic field. In Figure 1, starting from the bottom panel First, Second and Third panels show the cross plot between CME occurrence per month and Sunspot numbers for the epochs of $A>0$, Mix and $A<0$ polarity of solar magnetic field. Distributions of points in all the three epochs show positive and nearly high correlation these two solar and interplanetary indices. This proves that the CME occurrence is also a reliable interplanetary parameter and varies similar to sunspot numbers. Further in figure 2, CME occurrence per month has been correlated against the CRI for all the three epochs, $A>0$, $A<0$ and mix polarity. It is seen from figure 2, that CRI and CMEs occurrence are negatively correlated. However, the correlations are almost significant indicate a normal relation between them.



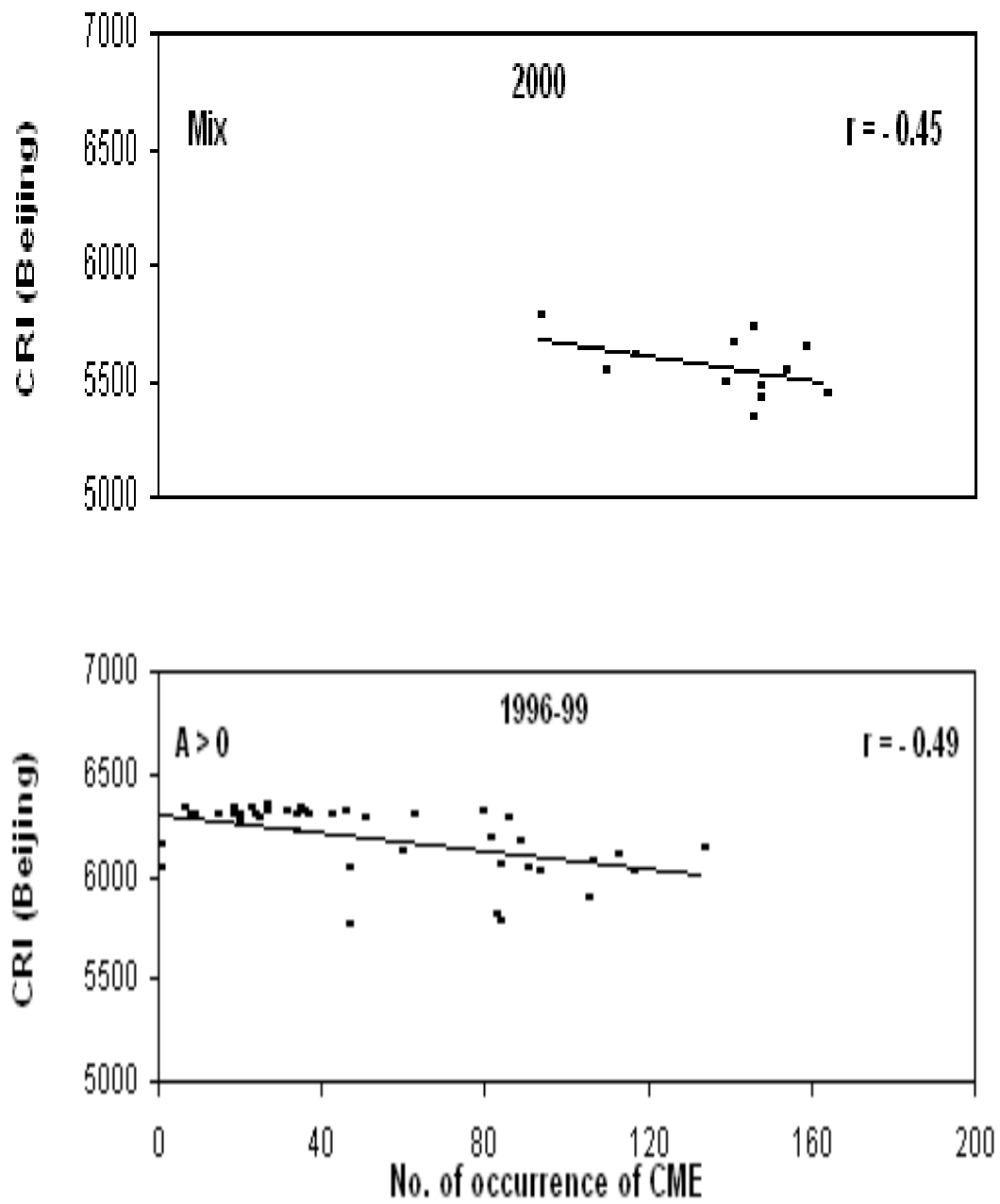


Figure 1 Correlation plot between No. of occurrence of CME per month and sunspot number (Rz) for epochs of (i) $A > 0$, (ii) $A < 0$ and (iii) mix polarity reversal periods.

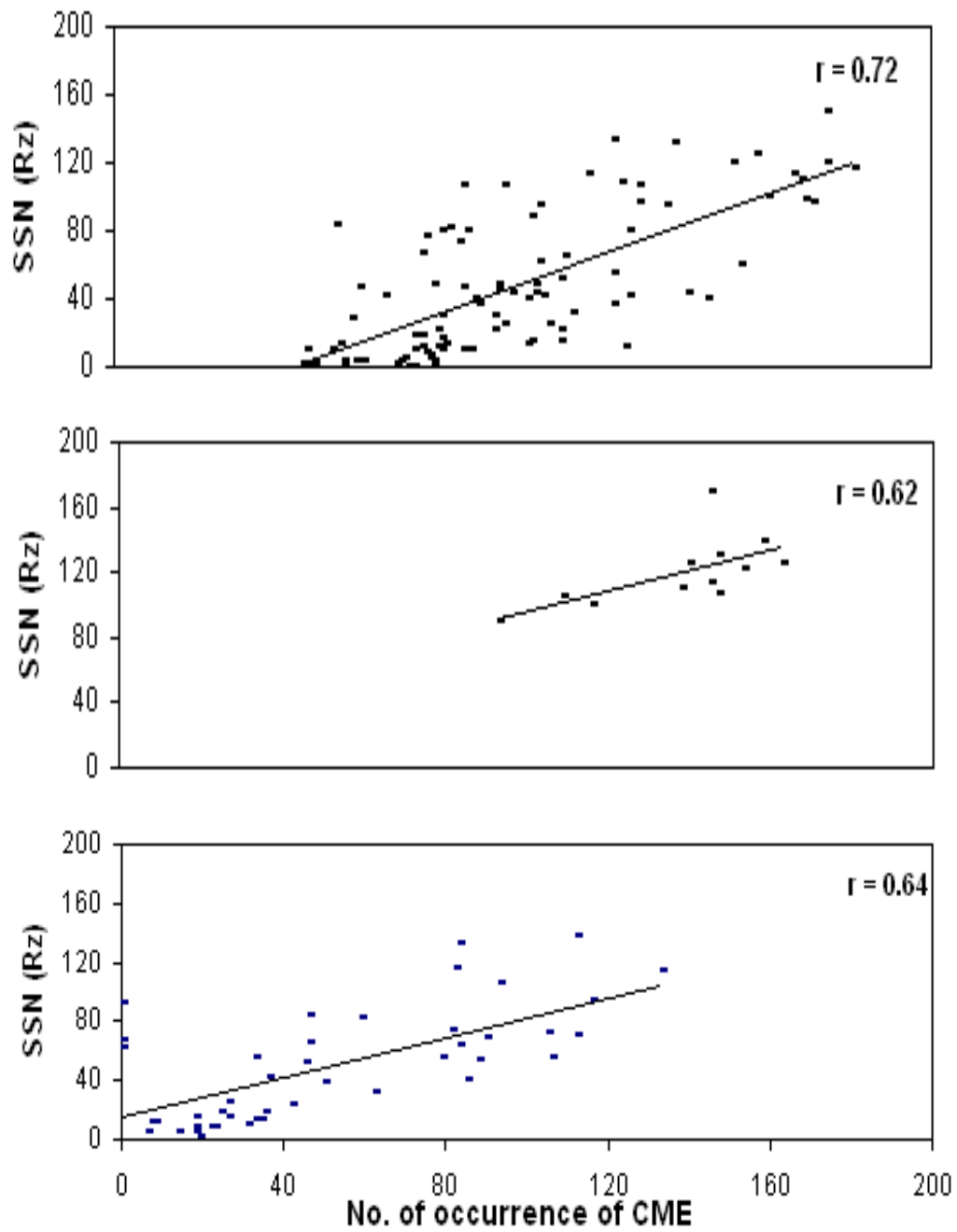


Figure 2 Correlation plots between No. of occurrence of CME per month and CRI for the epochs of (i) $A > 0$, (ii) $A < 0$ and (iii) mix polarity reversal periods.

CONCLUSION

From this analysis, it is concluded that:

1. Sunspot numbers and CMEs are correlated positively and high for the epochs of $A > 0$, Mix and $A < 0$ solar magnetic field.
2. Cosmic rays also show a significant correlation with CMEs occurrence for all the epochs of solar magnetic field.

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